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WATERSHED PROGRAM EVALUATION

East Willow Creek, Minnesota

ERS-231
ECONOMIC RESEARCH SERVICE/U.S. DEPARTMENT OF AGRICULTURE

PREFACE

East Willow Creek, a tributary of the Root River system, drains a 37.5-square-mile area of Fillmore County in southeastern Minnesota. A watershed protection plan for East Willow Creek was written in 1954 under authority of a U. S. Department of Agriculture Appropriation Act of the same year. This act provided for a pilot program of watershed protection to be initiated in 65 small watersheds throughout the United States.

The work plan for East Willow Creek Watershed outlined a program designed to reduce erosion, sedimentation, and flooding. It included land-treatment measures, dams for flood protection and land stabilization, and the improvement of subwatershed waterways. Construction of the project commenced in 1954 and was completed in 1959. An evaluation of the project was made to provide data that would be useful in planning other watersheds with similar problems and characteristics. This report reviews and analyzes results of project installations through 1960.

This report is the result of the joint efforts of the Minnesota State Conservationist's Office and the Engineering and Watershed Planning Unit, Lincoln, Nebr., (formerly Milwaukee, Wis.), Soil Conservation Service, and the Resource Development Economics Division, Economic Research Service. A. B. Daugherty and R. A. Blood, Agricultural Economists, Resource Development Economics Division, ERS, compiled and analyzed the watershed statistics collected by members of the ERS staff. Some of the field data were collected under the direction of Arnold Aakre, Work Unit Conservationist, Soil Conservation Service, Preston, Minn.

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Washington, D.C. May 1965

SUMMARY

Investment in all works of improvement installed in the East Willow Creek Watershed Project between 1954 and 1960 totaled $392,407. The structural measures cost $215,090 and the land-treatment measures $177,317. The number of structures installed for flood prevention, land stabilization, and sediment control was smaller than estimated in the initial project plan. Land-treatment measures replaced many of the planned structural measures.

The full impact of this comprehensive soil and water conservation program was not ascertained by this study. Analysis of this kind would require the collection and measurement of additional physical and economic data over a much longer period.

Land-treatment measures applied to farmlands through 1960 more nearly achieved the goals set forth at the time of planning than other features of the plan. The plan of work called for many interdependent conservation practices. The conservation practices applied to the land did not in all cases adhere to the recommendations set forth in the plan for watershed improvement. However, the practices applied did permit shifts in rotations that accomplished the plan's purpose, at least in part. These shifts in rotations, in conjunction with the conservation practices, permitted more intensive crop rotations, without increasing the amount of soil lost by sheet erosion. According to the sheet-erosion studies, on sample areas totaling nearly 14 percent of the watershed area, about 91 percent more cropland was at or below the allowable annual rate of soil loss to permit continued farming without causing permanent and continuing loss of productivity. These findings suggest that when future projects are planned for similar watersheds, a more rigorous evaluation of the needs for land treatment would provide a better balance between the structural measures and the land-treatment practices.

Net farm income in the East Willow Creek Watershed increased nearly $100,000 per year following installation of the project measures. This gain was due to higher crop yields, more intensive use of cropland, and larger numbers of livestock. The portion of this increased income creditable to the watershed project cannot be determined at this time since the evaluation methods employed were not sufficiently detailed to isolate the contributing variables.

No significant change in intensification of flood-plain land use was indicated by the recorded land-use data.

For the sample gullies observed, the rates of damage at the start of the evaluation were very low and the computed benefits were therefore inconsequential.

Although the evaluation program was not able to verify appraisals of the planned economic benefits of the project, it did provide insights toward improvements of future plans and evaluations. Changes in use of flood plains

are not completely dependent on changes in flooding. Similarly, conservation treatment of uplands needs to take account of other programs. More accurate appraisals of yield responses to conservation practices are essential if income changes are to be credited to such practices. Since there are numerous contributing variables, more precise research techniques will be required to analyze conservation benefits fully.

The influence of reductions in rates of sheet erosion on farm income is not discernible over short periods of observation. Attributable crop yield increases may be masked by effects of weather and differences in management. As with conservation responses, more refined methods of research are required to exclude the effects of other variables.

WATERSHED PROGRAM EVALUATION
EAST WILLOW CREEK, MINNESOTA

Economic Research Service
and
Soil Conservation Service

WATERSHED CHARACTERISTICS

East Willow Creek flows into the South Branch of the Root River, a short distance upstream from Preston, Minn. The watershed drains approximately 24,000 acres and constitutes about 17 percent of the total South Branch drainage area. The terrain varies from gentle to moderately steep slopes. The loess-capped ridge tops are nearly level, with deep, well-drained, medium-textured soils. The slopes adjoining the drainage-ways are narrow and steep, with the surface varying from shallow soils to rock.

Average annual rainfall based on a 51-year Weather Bureau record is 30.24 inches. Approximately 63 percent of this precipitation occurs from May through September, much of it falling as high-intensity, short-duration rainstorms.

Farming and farm-related services are the major occupations in the watershed. At the start of the project about 97 percent of the watershed land was within operating farm units. Water for domestic and livestock uses was derived mainly from shallow wells and small farm ponds. Principal uses of farmland were crops, on 18,845 acres--the major crops being corn, oats, and hay; and permanent pasture, on 3,564 acres. Cattle feeding and hog feeding were major enterprises on most farms. Only small quantities of crops were sold.

It was estimated in the work plan that an average of 405 acres of bottomland flooded annually (1,618 acres are subject to flooding). In addition to damages resulting from the inundation of crops and pasture, further damages were sustained from flood-plain scour and sediment. In the upland, serious erosion problems existed. The estimate of the annual topsoil loss at the time the project was formulated exceeded 280,000 tons. In many areas the original topsoil had measured 15 inches. Sheet erosion had removed one-quarter to one-half of the original topsoil from approximately 61 percent of the upland and one-half to three-fourths from another 32 percent of the upland. Before installation of the project, gully erosion, on the average, was making 12 acres of land per year unfit for agricultural production and was causing serious depreciation of an additional 74 acres. Intensive cropping systems and overgrazing of pastures without adequate conservation practices had contributed to the erosion problems.

Estimated average annual damages, appraised in 1954 and reevaluated in 1955 to provide an economic basis for recommending improvements, were as follows:

Floodwater damage:	
Flood-plain scour	$ 118
Streambank erosion	605
Agricultural (crops, pasture, fences, etc.)	1,850
Nonagricultural (public transportation facilities, urban, etc.)	5,958
Indirect	2,248
Subtotal	$10,779
Sediment damage:	
Infertile overwash	$ 1,192
Swamping	86
Transportation facilities	5,075
Subtotal	$ 6,353
Upland erosion damage:	
Sheet erosion	$39,743
Gully erosion	7,264
Subtotal	$47,007
Total	$64,139

The reevaluation of damages in 1955 indicated $800 greater annual damage from sediment in the form of infertile overwash; $3,000 greater annual sediment damages to transportation facilities; $3,408 more floodwater and sediment damages annually to urban areas; and $2,248 annual indirect floodwater damages more than were appraised in the original work plan.

Some watershed-improvement measures were installed before inception of the Pilot Watershed project. The West Fillmore Soil Conservation District, as of 1954, had assisted landowners and operators in preparing conservation plans for 54 farms. On the basis of total needs, approximately 3 percent of the engineering-type measures and 20 percent of the land-treatment measures had been installed with assistance from the Soil Conservation District. These accomplishments, no doubt, had alleviated flood, erosion, and sediment problems although their benefits were not evaluated. The estimates of annual damages from floodwater, sediment, and erosion set forth above are those estimated to occur with watershed conditions as they existed at the time the project was planned.

PROGRAM OF IMPROVEMENT

Planned Program

The plan for watershed improvement, formulated in September 1954 and revised in December 1955 by the Soil Conservation Service (SCS) and the local sponsors, contained recommendations for two general groups of conservation measures; namely, those designated as A measures for flood prevention and those designated as B measures for conservation of water and watershed lands.

The A measures, primarily structural, were planned to function in combination with vegetative measures (B measures). Stabilization and sediment-control structures (A measures) were planned to arrest gully development, stabilize waterways, and reduce sediment damages. Flood-retarding and erosion-control structures were planned to control runoff from a considerable portion of the watershed. These structures were to be earth fills, with pipe or formed-concrete-box outlets. Subwatershed waterway improvement, stream-channel improvement, and the stabilization of critical runoff and sediment-producing areas were planned to reduce runoff and sediment.

The B measures included land use adjustments, changes in rotations, contour stripcropping, terraces, field diversions, terrace outlets, farm waterways, and other conservation practices normally used in the area. Pasture improvement and wildlife-area development were planned to reduce runoff and sedimentation from areas of sparse vegetation and small, inaccessible, odd-shaped tracts of land. Tree planting was planned for 522 acres to provide vegetative cover and to reduce erosion and runoff by protecting the soil and increasing infiltration and water-holding capacity on areas unsuitable for more intensive uses.

The amounts of the respective A and B measures included in the work plan, September 1954, those included in the revised plan of December 1955, and those installed as of June 30, 1960, are listed in table 1. The 1954 plan was revised by local landowners and SCS planning technicians. As the landowners gained knowledge of the program, they perceived that many of the desired results could be accomplished at less cost by land-treatment practices than by structural measures. The planners realized that the complete conservation program originally specified could not be achieved. Consequently, the plan was revised to show more accurately the program which could be installed. The estimated costs of installing the original and revised programs of improvement, and the cost of the measures actually installed, itemized by type of measure, are given in table 2. These estimated costs are exclusive of the expenses for developing the work plans and of those for project evaluation.

Estimated Benefits

Listed below are the average annual benefits which were expected to result from the revised program of watershed improvement as set forth in table 1:

Reduction of floodwater damage	$ 3,362
Reduction of sediment damage	3,698
Reduction of indirect floodwater and sediment damage	1,393
More intensive use of flood plain	2,210
Reduction of sheet erosion	38,341
Reduction of gully erosion	1,236
Conservation benefit	61,508
Total annual watershed protection benefit	$111,748

The major benefits from reduction in flooding would accrue to farmers of flood-plain lands, and to the County Board and Highway Department through lowered annual maintenance and repair of roads and bridges. Sediment-damage

Table 1.--Works of improvement recommended, September 1954; revised, December 1955; installed, June 30, 1960, East Willow Creek Watershed, Minn.

Measures recommended	Unit	Number: Original work plan Sept. 1954	Revised work plan Dec. 1955	Installed as of June 30, 1960
A measures:				
Grade stabilization structures	Each	41	16	15
Floodwater-retarding structures	Each	12	7	6
Subwatershed waterway improvement	Mile	25	3	0
Stream-channel improvement:				
Streambank and channel stabilization	Mile	3	3	0
Stabilization of critical runoff and sediment-producing areas:				
Roadside erosion control	Mile	5	0	0
Woody plantings	Acre	20	17	0
B measures:				
Land-use adjustment	Acre	17,350	17,350	13,503
Stripcropping (contour)	Acre	6,012	5,512	5,023
Terraces	Mile	227	94.5	50
Terrace outlet construction	Mile	14.5	8	5
Pasture seeding	Acre	1,027	1,027	966
Waterway development	Acre	44.5	60	133
Diversion construction	Mile	2.5	5	14
Wildlife establishment	Acre	179	117	43
Farm planning and application assistance	Acre	10,732	10,732	19,560
Tree planting:				
Stand reinforcement	Acre	151	151	116
General reforestation	Acre	371	371	30
Forest management assistance	Acre	1,069	1,145	511

reduction was expected to provide additional benefits to the Highway Department and to Preston, Minn., which in the past has suffered varying amounts of damage from sediment and debris. Some benefits would be derived from more intensive use of flood-plain lands as a result of the mitigated flood risk.

Reduction in sheet and gully erosion was expected to allow shorter rotation systems, higher crop yields, and lower costs of production than would be possible without the project.

Table 2.--Costs, estimated, September 1954; revised estimate, December 1955; incurred as of June 30, 1960, East Willow Creek Watershed, Minn.

Measures recommended	Estimated cost: Original work plan Sept. 1954	Estimated cost: Revised work plan Dec. 1955	Actual cost: Installed measures June 30,1960
A measures:	Dollars	Dollars	Dollars
Grade stabilization structures	149,020	30,112	35,348
Floodwater-retarding structures	219,500	157,278	179,742
Subwatershed waterway improvement	51,057	6,000	0
Stream-channel improvement:			
Streambank and channel stabilization	6,900	12,000	0
Stabilization of critical runoff and sediment producing areas:			
Roadside erosion control	1,197	0	0
Woody plantings	1,538	1,099	0
Total A measures	429,212	206,489	215,090
B measures:			
Land-use adjustment	33,782	33,782	27,060
Stripcropping (contour)	20,282	18,519	16,820
Terraces	26,872	12,154	5,850
Terrace outlet construction	3,172	1,750	6,725
Pasture seeding	40,879	40,874	40,800
Waterway development	1,774	2,400	5,010
Diversion construction	1,863	3,720	8,000
Wildlife establishment	2,536	1,651	750
Farm planning and application assistance	32,197	28,197	49,510
Tree planting:			
Stand reinforcement	3,649	3,650	2,804
General reforestation	14,383	14,382	10,893
Forest management assistance	5,589	3,941	3,095
Total B Measures	186,978	165,020	177,317
Estimated total project costs 1/	616,190	371,509	392,407

1/ Excluding the costs of developing the work plan and of project evaluation.

Conservation benefits were expected to accrue from the utilization and treatment of farmlands more nearly according to their needs and capabilities, with correspondingly higher net returns.

Program Installed

At the time the project was authorized in 1953, the West Fillmore Soil Conservation District had been in operation for 11 years. Of the 155 farms in the watershed, owners of 81 of the farms had signed standard Soil Conservation District agreements, signifying their intention "to carry out recommended soil conservation measures and proper farm plans" (district cooperators).1/ For 54 of these farms, basic plans had been prepared for the use of all land within its capabilities, and conservation treatment for the land, within practical limits, according to the chosen use to prevent further deterioration of the soil and water resources. Upon completion of the project in 1959, the number of cooperators had increased to 143 and the number of farms having basic plans to 99.

Considerably fewer works of improvement were installed in the project area than originally planned and, for most of the measures, fewer were installed than were recommended in the revised plan, December 1955. Table 1 lists the amounts and table 2 lists the costs of the measures installed as of June 30, 1960.

Of the A measures, 16 grade stabilization structures were recommended in the revised program of improvement and 15 were installed (fig. 1). Six floodwater retarding structures were installed--also one less than the number recommended in the revised plan. The subwatershed waterway and stream-channel improvements were eliminated because it was determined during the installation period that benefits accruing to these measures would not justify their cost. Roadside erosion control was expected to be carried out by the county government without Federal assistance, so this measure was not included in the revised plan.

In comparing the amounts of B measures installed with those recommended, only three measures exceeded the amounts recommended in the revised plan. These were diversion construction, waterway development, and farm-planning assistance. Land-use adjustments, contour stripcropping, and pasture seeding were installed on about 80 percent of the area for which they were recommended. The amounts installed of the remaining B measures averaged 50 percent of the quantities planned. The portions of the individual measures varied from tree planting (28 percent of the area planned) to terrace outlet construction (62 percent of the amount recommended in the revised plan).

Installation of the planned watershed project was implemented by a steering committee of 17 farmers appointed by the local project sponsors.

1/ U. S. Department of Agriculture, Watershed Protection Handbook, Part 1 - Planning. Soil Conserv. Serv., July 1961.

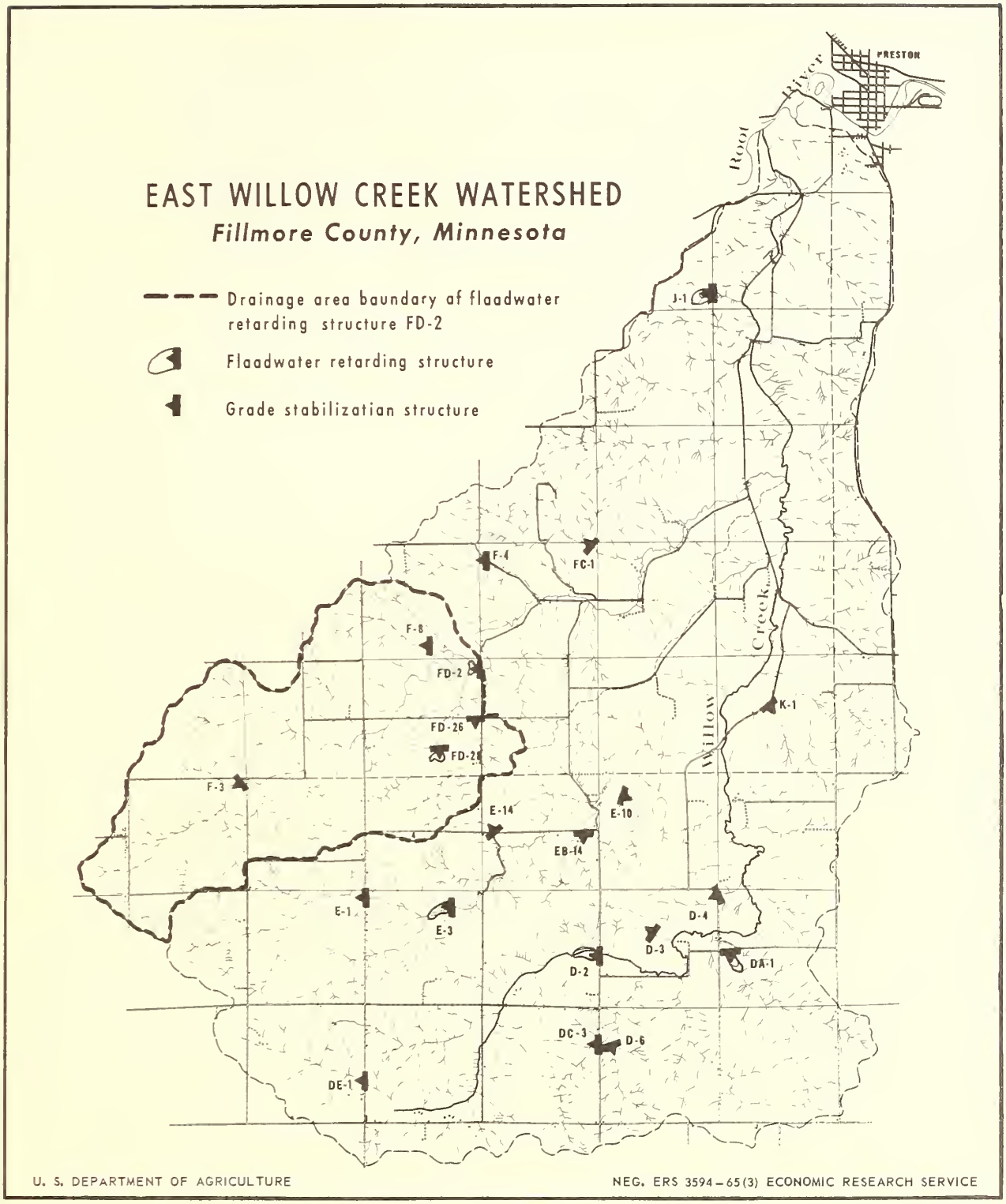

Figure 1.--Structure location map, East Willow Creek Watershed, Minnesota.

This committee was given the responsibility of informing farmers and others in the watershed of the project's objectives, generating interest in the program, and obtaining all easements and rights-of-way for the structures.2/

This committee of local farmers was instrumental in reducing the number of structural measures below the number originally recommended because, in their judgment, all were not economically justified. This action shifted more of the cost to the local people by placing greater emphasis on B measures, thus considerably reducing, from the original plan, the amount of public funds invested in the project.

The total cost of the installed program of improvement was $392,407, of which $215,090 was for A measures and $177,317 was for B measures. These costs are approximately 50 percent less and 5 percent less, respectively, than the cost estimates of the original plan. However, they exceed the revised estimates of cost by $8,601 for the A measures and $12,297 for the B measures. The total cost of the program installed exceeded the cost estimate of the revised program of improvement by about 6 percent. In reviewing tables 1 and 2, the greatest effect on the increase in the cost of the A measures is the higher cost of the floodwater and erosion-control structures. This may be a result of higher construction costs at the time of project installation than were estimated, or changes in the design of the structures, or both. In the B, or conservation, measures, increased unit costs are especially noticeable for terrace outlet construction, general reforestation, and forest management assistance. The unit cost of diversion construction was considerably less than was estimated in the revised plan. However, the major influence on the absolute increase in the cost of the B measures installed has been the cost of farm-planning assistance. Although the unit cost for this measure decreased from the estimate in the revised plan, the amount of this measure increased by more than 80 percent, increasing the cost of the measure by $21,313 or nearly 76 percent.

PROGRAM EVALUATION

The evaluation study of East Willow Creek Watershed Project included measurement and appraisal of such factors as rainfall, runoff, erosion, land use, crop yields, and production. Data were gathered from two sample areas: flood plain and upland. The flood-plain sample, which consisted of the 803 acres of flood plain downstream from structure FD-2 (fig. 1), was 49.6 percent of the flood plain in the watershed. The upland sample was 3,515 acres of drainage area above structure FD-2 and 15.7 percent of the upland in the watershed. Instrumentation was provided only for these sample areas.

Figure 2 shows a view of floodwater-retarding structure FD-2, looking upstream. A county road runs on top of the structure. The land above the structure and road in figure 2 is part of that included in the upland sample area.

2/ For detailed account of local organization and administration of the watershed project, see Coleman, William J., Watershed Organization Appraisal, East Willow Creek Pilot Project in Minnesota, Agr. Res. Serv., U. S. Dept. Agr., Oct. 1960.

SCS Neg. Mn-298-3

Figure 2.--Floodwater-retarding structure FD-2.

Insofar as feasible, data were assembled for 1954 through 1960. They represent conditions before, during, and after project installation. Income changes were computed on the basis of changes in land use, yields, and production. Allocation of this income, however, to specific project measures or groups of measures was not possible in most instances because of the multiplicity of variables.

Appraisals were made of income changes derived from flood prevention, conservation, and reduction of gully erosion. Appraisals were also made of changes in rates of sheet erosion and sedimentation, but monetary values were not assigned to the physical measurements. Substantial income changes are presented later in this report under the heading of "Conservation." These arise from significant changes in intensity of cropland use, crop yields, and livestock numbers. Establishment of a causal relationship of these changes with the watershed project represents a major research problem. Methods of study employed by this survey were not adequate for this purpose.

Flood Prevention

Only one storm during the evaluation period was severe enough to cause appreciable flooding. For this storm of June 25, 1959, rainfall records were obtained from 34 gages in or near the watershed. For the watershed as a whole, the precipitation averaged 3.5 to 4.0 inches.

To determine how much land was flooded and how much would have been flooded if the project measures had not been installed, use was made of hydrologic methods devised for watershed planning.3/ Runoff characteristics of the watershed associated with land use, soil types, and antecedent moisture conditions were estimated from survey data. Stream stages versus peak water discharge were calculated for 27 cross sections of the valley. Peak water discharges, taking account of reservoir storage, were related to acres of land inundated at various depths. Effects of the installed works of improvement on the 1959 flood in terms of acreage flooded are as follows:

Depth	Acres inundated		
	With project	Without project	Difference
2 feet deep or less	147	171	24
2.1 to 4.0 feet	50	100	50
4.1 feet or more	19	40	21
All depths	216	311	95

Reduction in Flood Damage

Farm operators of flood-plain land below the sample area (structure FD-2) were interviewed to find out what floodwater damages they sustained with the project in place. A summary of the data obtained in these interviews indicated that crop and pasture damage from this flood averaged $11.12 per acre flooded. Other agricultural damage averaged $4.49 per acre flooded. Hydrologic analysis of this storm indicated that 311 acres would have been flooded without structure FD-2 in place. The estimate of area flooded with this structure in place was 216 acres--95 acres less than under uncontrolled conditions. This estimate of reduction in area flooded does not account for control afforded by floodwater-retarding and other control structures outside the sample area. Assuming the same rate of damage on the 95 additional acres that would have been flooded without the project, the crop and pasture damage prevented by structure FD-2 was $1,056. Similarly, other agricultural damage prevented was $427, making a total agricultural benefit from the structure of $1,483 for floodwater reduction during this flood.

The hydrologic analysis was not of sufficient detail to allow the estimation of the nonagricultural benefits from reduction of floodwater and sediment during the June 25, 1959, storm. It was expected that these types of benefits would accrue both within and outside the project area. An article concerning the June 25, 1959, flood that appeared in The Preston Republican, Preston, Minn., on July 2, 1959, indicated in part:

"Flood damage at Preston was kept to a minimum by the Willow Creek Watershed Project which was completed last year. Last Thursday night's flood was the first real test of the watershed program except for the spring thaw.

3/ U. S. Department of Agriculture, National Engineering Handbook, NEH-4, Suppl. A, p. 3.14-1, Soil Conserv. Serv., 1957.

The six major dams in the watershed were nearly filled, and Arnold Aakre, Fillmore County Soil Conservation Agent, tells us that the structures held back an estimated 1,200 acre feet or approximately 400 million gallons."

Land-Use Intensification

In addition to benefits resulting from reduction in flood damages, additional benefits were expected to accrue as a result of more intensive use of flood-plain lands. It was expected that reduced frequency and magnitude of floods would induce farm operators to grow higher valued crops on the flood plain than they had previously. The estimated benefit, however, was slight, being approximately 2 percent of total project benefits, or $2,210 annually.

To estimate land-use intensification, annual land use and crop yields were compiled from surveys of farmers operating flood-plain lands below structure FD-2. These data for the 1954-57 base period and for 1958 through 1960 are presented in table 3. Using these data and long-term projected prices, the values of crop and pasture production were computed for the base period and for each subsequent year.4/ These gross values of production are presented in the first part of table 4. Values of production as shown reflect changes in cropping patterns and yields only, as constant prices were utilized throughout. To further identify the singular effect of changed land use, average yields for 1954 through 1957 and long-term projected prices were used in conjunction with the recorded uses of land each year to compute values of flood-plain production. These values are shown in the second portion of table 4. They indicate that in 1958 and 1960 the land-use pattern was less intensive than during the base period; in 1959 it was considerably more intensive. On the average, the use of the flood plain was just slightly more intensive during 1958 through 1960 than during the base period.

Because crop rotation systems in this area are primarily 4- and 5-year systems, and the evaluation data cover only a 3-year period, no conclusive statements can be postulated concerning land-use trends. In the future, when the reduction in flood risk is more fully recognized and data for a long period are available, a pattern of land-use changes may become identifiable.

Sheet Erosion

Sheet erosion was studied on 22 tracts of land, averaging 152 acres, randomly selected to represent the 24,000-acre East Willow Creek Watershed. The sample tracts were identical to those examined during the development of the original work plan. The aggregate sample of 3,340 acres included approximately 301 acres of land having slopes of 2 percent or less. These areas were considered as "depositional areas" and were excluded from sheet-erosion computations.

Within the time and resources available, it was not feasible to measure soil-erosion losses by direct means. Instead, use was made of an established predictive model.5/ This model treats the volume of sheet erosion for a given

4/ U. S. Department of Agriculture, Agricultural Cost and Price Projections, Agr. Res. Serv. and Agr. Mktg. Serv., Sept. 1957.

5/ Musgrave, G. W. The Quantitative Evaluation of Factors in Water Erosion--A First Approximation. Soil and Water Conserv. Jour., 2(3) 133-138, July 1947.

Table 3.--Annual land use and yields; flood plain, East Willow Creek Watershed, Minn., 1954-60

Item	Average 1954-57	1958	1959	1960	Average 1958-60
			Acres		
Land use:					
Corn	279	244	341	269	285
Oats	52	32	45	19	32
Wheat	4	15	0	0	5
Soybeans	4	73	0	0	24
Hay	66	19	40	33	31
Peas	0	0	0	75	25
Pasture	314	306	339	341	329
Misc. and idle	18	72	5	23	33
Other 1/	66	42	33	43	39
Total	803	803	803	803	803
			Bushels		
Average yields:					
Corn	71	66	78	77	74
Oats	51	58	35	66	49
Wheat	30	35	-	-	35
Soybeans	25	24	-	-	24
			Tons		
Hay	3.0	3.0	2.3	2.8	2.6
Peas	-	-	-	1.2	1.2
			Animal unit months		
Pasture	3.2	3.3	4.9	3.3	3.9

1/ Includes buildings, lots, roads, bridges, creeks, creek beds, woodland, wasteland, and gullies.

soil unit as a function of the following variables: Land use, crop rotation, degree and length of slope, rainfall, and soil conservation practices.

Prior to project installation, a record of these variables had been maintained for each sample tract. A comparable inventory was compiled for conditions prevailing after project installation. The reduction in erosion losses was estimated by applying the predictive equation to both sets of variables. Tables 5 and 6 present a summary of the results. On the 3,039 acres subject to sheet erosion, there was practically no change in the major land-use categories. Cropland changed from 2,349 acres before the project to 2,322 acres after, and pasture decreased from 285 acres to 277. However, this decrease of 27 acres of cropland and 8 acres of pasture equal the 35 acres in the Soil Bank after project installation. The land in other uses remained constant with no changes in rates of erosion.

Table 4.--Value of production, flood plain, East Willow Creek Watershed, Minn., 1954-60

Item	Average 1954-57	1958	1959	1960	Average 1958-60
Production value (long-term prices)	Dollars				
All crops	31,375	28,361	37,670	32,578	32,870
Pasture	3,750	3,756	6,179	4,174	4,703
Total	35,125	32,117	43,849	36,752	37,573
Production value (long-term prices and average yields 1954-57) 1/					
All crops	31,375	29,862	35,424	30,356	31,881
Pasture	3,750	3,642	4,035	4,047	3,908
Total	35,125	33,504	39,459	34,403	35,789
Change in returns due to changed land use	0	-1,621	+4,334	-722	+664

1/ Due to the lack of production of peas in the 1954-57 period, the 1960 yield was used for this analysis.

For 3,039 acres of the sample area subject to sheet erosion, the rate of erosion declined from 31,225 tons per year to 19,325 tons, a reduction of approximately 38 percent. Most of this reduction occurred on cropland, where erosion losses were reduced from 30,013 tons per year to 18,102 tons per year--a reduction of nearly 40 percent. In terms of tons per acre of cropland affected, the annual rate declined from 12.8 tons to 7.8 tons. Before project installation, 503 acres of cropland were eroding at less than the maximum allowable rate.6/ In 1960, cropland in this category increased to 963 acres. This reduction in sheet erosion is attributed to the greater application of conservation practices on cropland. The amount of contour stripcropping increased 34 percent; contouring, 152 percent; and terracing, 1,138 percent. Taken as a whole, these changes doubled the acres of cropland subject to

6/ The maximum allowable rate of soil loss for most soils in this area is 4 tons per acre per year. It varies, however, from 2 to 4 tons per acre per year, depending on the specific soil involved.

Table 5.--Sheet erosion losses before and after project installation, sample area, East Willow Creek Watershed, Minn., 1954-60

Characteristics of area	Before project		After project	
	Size of area	Sheet erosion losses per year	Size of area	Sheet erosion losses per year
	Acres	Tons	Acres	Tons
Total area of sample	3,340	-	3,340	-
Slope of 2% or less	301	-	301	-
Area subject to sheet erosion	3,039	31,225	3,039	19,325
Cropland	2,349	30,013	2,322	18,102
Pasture	285	337	277	330
Timber	243	216	243	216
Building and lots	108	467	108	467
Roads	50	159	50	159
Soil bank	-	-	35	18
Miscellaneous	4	33	4	33

Table 6.--Cropland practices and annual soil losses before and after project installation, sample area, East Willow Creek Watershed, Minn., 1954-60

Item	Unit	Before project	After project	Percentage change
Cropland Practices:				
Stripcropping	Acres	519	694	+34
Contouring	Acres	92	232	+152
Terracing	Acres	32	396	+1,138
Annual soil loss per acre of:				
Cropland	Tons	12.8	7.8	-39
All land subject to sheet erosion	Tons	10.3	6.4	-38
Total sample area	Tons	9.3	5.8	-38
Cropland with annual erosion of 4 tons or less per acre	Acres	503	963	+91

conservation treatment. By 1960, conservation practices had been installed on 57 percent of the cropland recommended for treatment, in contrast to 27 percent at the start of the watershed-protection project.

Gully Erosion

Late in the summer of 1958, field observations were made on eight gullies to determine their width, depth, and rates of headward advance. The five gullies active at that time were observed again in the fall of 1960 to determine the significant changes which occurred following the 1958 observations. Of the five gullies, two were almost healed over and, for all practical purposes, were under control. Since those gullies were only 10 feet wide and estimated to be advancing about 1 and 2 feet per year, respectively, in 1958, stabilizing them prevented the voiding of very little land. The other three gullies observed were between 4 and 8 feet deep, and 10 to 20 feet wide. Two were advancing 1 to 2 feet per year and the third 10 feet per year. Those rates of advance were unchanged from the rates observed in 1958. Gullies with rates of advance of 1 to 2 feet per year are considered to be relatively inactive.

The most active gully, advancing 10 feet per year, would void 25,000 square feet (approximately 0.57 acre) in 50 years. The advance of the gully may isolate some areas, making them inaccessible to machinery and impractical to cultivate. If these "depreciated" areas are assumed to be double the size of the area voided, approximately 1.7 acres would be damaged in 50 years if the present rate of advance of this gully continues.

It appears that most gullies in this watershed can be controlled by shaping their banks and heads, establishing vegetation on the disturbed areas, and applying good management practices to the treated gullies and the lands draining into them.

Observations were made of the other gullies in the 3,938-acre drainage area of floodwater-retarding structure FD-2. There are four structures upstream from this site. One is a floodwater-retarding structure (FD-28) having a drainage area of 388 acres. The others are stabilization structures F-3, F-8, and FD-26 (fig. 1). They are similar to the gully-stabilization structure shown in figure 3.

In the absence of structures F-3, F-8, FD-26, and FD-28, 2.13 acres would have been voided and 3.00 acres depreciated in a 50-year period. Thus, these structures have prevented the voiding of 0.043 acre and the depreciation of 0.060 acre annually. The annual value of the losses prevented is inconsequential; an estimate of the benefit is shown in appendix table 10.

Sedimentation

Sedimentation surveys were made in March 1960 at floodwater-retarding reservoirs DA-1 and E-3. Figure 4 depicts floodwater-retarding structure E-3 nearing completion. This photograph was taken in the fall of 1955.

SCS Neg. Mn-203-4

Figure 3.--Gully-stabilization structure E-10.

SCS Neg. Mn-48-7

Figure 4.--Floodwater-retarding structure E-3.

Normal storage began in E-3 in March 1956, and DA-1 in November 1956. The initial surveys for the sedimentation studies were made on May 8, 1957, for E-3, and June 24, 1957, for DA-1; these dates are the starting times for sediment measurements. The drainage areas for these reservoirs, including the impoundment areas, are 840 and 1,960 acres, respectively.

Although some difficulty was experienced in securing an accurate measurement of all sediment reaching reservoir DA-1, due to the development of a sinkhole in the pool area, the results of the survey appear to be reasonable. The sinkhole was repaired in 1958 and apparently was in satisfactory condition when the sedimentation survey was made in 1960. The results of the survey of reservoir DA-1, which contains 1.31 square miles of drainage, shows that the rate of sediment accumulation during the 2.75-year period between the initial sedimentation survey in 1957 and the survey in March 1960, averaged 0.65 acre-foot per square mile per year. This is equal to slightly more than 1.5 tons per acre per year at a dry weight of 70 pounds per cubic foot. These figures are based on the measured sediment accumulation, but do not include an adjustment for the sediment which may have passed through the sinkhole. The sedimentation survey of DA-1 shows that 33.4 acre-feet of storage were available for sediment. The rate of accumulation from May 1957 to March 1960 was 0.82 acre-foot per year; at this rate, the available storage will last approximately 41 years. The design life of the structure is 50 years. Therefore, the sediment storage will be exhausted in less than 50 years, assuming this rate of accumulation continues in the future. However, the period of measurement was only 2.75 years and since no analysis was made of the times or intensities of precipitation during the period, the measured accumulation may not adequately reflect the long-time rate.

Due to considerable reworking of the upper end of the pool area of reservoir E-3 between surveys, it was impossible to make reliable measurements of sediment accumulation. Consequently, no data on sediment accumulation are available for this reservoir. The 1960 survey is expected to provide a base from which future accumulations can be determined.

As resurveys are made, average annual rates of accumulation will become more reliable for predicting the remaining life of the sediment storage. Plans for the evaluation studies provide for resurveying these reservoirs at 3-year intervals; the first resurvey was made in 1963.

Conservation

When the revised plan of watershed improvement for the East Willow Creek Watershed Project was prepared in December 1955, it was estimated that conservation benefits from the installed project would average more than $61,500 annually. These benefits were expected to accrue primarily as result of increased crop yields. An additional benefit of $38,340 was estimated to result from reduced sheet erosion. Thus, estimated benefits from changes in land use, increased crop yields, and decreased production costs totaled nearly $100,000.

Land-treatment measures such as terracing, stripcropping, and contour farming were planned in conjunction with structural measures for reducing sheet and gully erosion. Figure 5 is an aerial view of some of the typical land and water conserving practices in the watershed in 1957. The structure just to the right of center in the photograph is floodwater-retarding structure E-3, shown earlier in figure 3 in final stages of construction.

Land-use adjustments were recommended in order that more land in the watershed would be used according to its capability. The land-use adjustments recommended would have resulted in a net reduction of 315 and 237 acres of cropland and pasture, respectively. Idle land would have decreased 77 acres while forests and wildlife areas would have increased 446 and 183 acres.

The quantities of the respective land-treatment measures recommended for the project area and the amounts of the measures installed are listed in table 7. Only two measures, waterway development and diversion construction, were installed in greater amounts than were recommended.

SCS Neg. Mn-175-3

Figure 5.--Typical land and water conserving practices in East Willow Creek Watershed.

Table 7.--Land treatment, East Willow Creek Watershed, Minn., 1960

Measures	Unit	Amount needed 1/	Amount applied to 1955	Amount applied to 1960
Land-use adjustments	Acre	20,240	2,890	16,393
Stripcropping	Acre	8,212	2,700	7,723
Terraces	Mile	98.4	3.9	53.9
Terrace outlet construction	Mile	8.5	0.5	5.5
Pasture seeding	Acre	1,327	300	1,266
Waterway development	Acre	69.7	9.7	142.7
Diversion construction	Mile	5	-	14
Wildlife establishment	Acre	122	5	48

1/ As set forth in the East Willow Creek Watershed Work Plan, December 1955.

The land-use conversions that were made in the watershed after 1955 were as follows:

Cropland to pasture---------- 58 acres
Pasture to cropland---------- 25 acres
Pasture to woodland---------- 19 acres
Woodland to cropland---------- 35 acres
Woodland to pasture---------- 14 acres

The net result of these land-use changes was 2 acres more cropland, 28 acres more pasture, and 30 acres less woodland.

Land use and production in the sample area above structure FD-2 were analyzed in an attempt to appraise some of the changes attributable to conservation. Land use and yields for the 1954-57 base period and annually for succeeding years are shown in table 8. Gross values of production are shown for the same years in table 9. A comparison between the base period and the 1958-60 evaluation period shows that there was a shift toward more intensive land use. Further analysis of the data in these tables indicated that about 70 percent of the average $21,369 gain in annual gross returns during the evaluation period resulted from changes in the pattern of land use, exclusive of the effects of changes in crop yields. This change in land use contrasts with that found in the flood plain, where the land-use intensity was not significantly different after the project was installed.

Removal of corn acreage controls in 1958 probably stimulated cropping intensification. Soybean and wheat acreage showed increases during this same period. The added acreage planted to these crops appears to have been taken primarily from oats and meadow, since pasture acreage remained relatively stable. The value of corn production increased about 25 percent and that of other crops, which include soybeans and wheat, increased nearly 59 percent. Values of the less intensive crops--oats, hay, and pasture--decreased 9, 14, and 6 percent, respectively.

Table 8.--Annual land use and yields, sample area FD-2, East Willow Creek Watershed, Minn., 1954-60

Land use	Average 1954-57		1958		1959		1960		Average 1958-60	
	Acres	Yield per acre	Acres	Yield per acre	Acres	Yield per acre	Acres	Yield per acre	Acres	Yield per acre
Corn-----	1,133	77 bu.	1,343	77 bu.	1,448	83 bu.	1,304	79 bu.	1,365	80 bu.
Oats-----	770	52 bu.	577	54 bu.	749	56 bu.	671	54 bu.	666	55 bu.
Wheat----	-	-	-	-	32	47 bu.	14	30 bu.	15	42 bu.
Soybeans-	60	26 bu.	104	26 bu.	49	33 bu.	67	25 bu.	73	27 bu.
Hay------	974	3.0 tons	954	2.7 tons	664	3.0 tons	917	3.2 tons	845	3.0 tons
Pasture--	498	4.8 AUM	478	4.9 AUM	527	4.7 AUM	510	3.8 AUM	505	4.5 AUM
Other----	80	-	59	-	46	-	32	-	46	-
Total--	3,515	-	3,515	-	3,515	-	3,515	-	3,515	-

Table 9.--Value of production, sample area FD-2, East Willow Creek Watershed Minn., 1954-60

Land use	Average 1954-57	1958	1959	1960	Average 1958-60
	Dollars				
Corn	115,158	136,503	158,643	135,981	143,709
Oats	27,628	21,499	28,941	25,001	25,147
Hay	43,538	38,379	29,681	43,723	37,261
Pasture	8,892	8,712	9,214	7,209	8,378
Other crops	3,557	6,165	6,244	4,533	5,647
Total	198,773	211,258	232,723	216,447	220,142
	Percentage change from 1954-57				
	Percent				
Corn	0	+18.5	+37.8	+18.1	+24.8
Oats	0	-22.2	+4.8	-9.5	-9.0
Hay	0	-11.8	-31.8	+0.4	-14.4
Pasture	0	-2.0	+3.6	-18.9	-5.8
Other crops	0	+73.3	+75.0	+27.4	+58.8
All crops	0	+6.3	+17.1	+8.9	+10.8

When gross returns that would have been realized from the actual yields and 1954-57 land use were computed, the effects of yield changes were quantified exclusive of the effect of changes in land use. This computation gave the following results:

	Gross returns	Change from base period
1954-57 base period	$198,773	$ -
1958	195,667	-3,106
1959	210,643	+11,870
1960	203,739	+4,966
Average 1958-60	$203,350	$ +4,577

Had the changes in yields taken place without any change in land use crop returns above structure FD-2 would have been $3,106 less in 1958 than during the base period, but $11,870 and $4,577 greater in 1959 and 1960, respectively. On the average, annual gross returns would have been $4,577 larger.

The gross returns shown earlier in table 9 indicated an average increase of $21,369 during the evaluation period over that of the base period. Since only $4,577 of this increase can be attributed to the singular effect of changes in crop yields, then changed land use is one of the major factors effecting increased returns.

The increased returns from changed land use have resulted primarily from changes in the distribution of land among crops, rather than from an increase in the acreage of cropland. The increase in the acreage of all crops averaged only about 1 percent over that of the base period. However, there was an average increase of slightly over 20 percent in corn acreage and 23 percent in soybeans.

For the 3-year evaluation period, gross crop and pasture returns averaged $6.08 more per acre of land above structure FD-2 than during the base period. Assuming the area above structure FD-2 is representative of the total watershed in terms of land use, crop yields, and land-treatment measures applied, this figure when expanded to the watershed would indicate an increase in gross returns of approximately $126,000.

Conservation benefits of the watershed project were also studied through a sample of 26 farms selected at random throughout the watershed. The operator of each sample farm was interviewed in 1955 to obtain data on land use and crop yields, livestock, and conservation measures on the farm. Similar data were obtained for 1960. The 1955 data were used in this analysis to represent the farms before installation of the project; 1960 data to represent them after project installation. Five of the farms were discarded from the analysis because of drastic changes in their organization. Two of the farms changed from partnerships to individual operations; two farmers purchased more than twice the amount of land they had operated in 1955; and one farmer retired.

Each of the sample farms was basically a livestock farm, producing most of its own feed supply. For the analysis, however, the crop or feed-growing enterprise was separated from the livestock enterprise. Land use, yields, and net returns from crops on the sample farms are shown for 1955 and 1960 in appendix tables 12 and 13. Acreages and yields reported by the farm operators were used to compute the gross return from each crop, using constant product prices for both periods. Average costs of production for each crop were estimated from secondary sources of data available from existing research. The cost of rented land was computed at $20 per acre. In 1955, this charge was made against 112 acres in corn, 120 acres in oats, and 58 acres in alfalfa. No rented cropland was indicated in the 1960 survey.7/

7/ One influence on the renting of land in 1955 may have been the corn acreage controls. Land may have been rented for the right to use the corn acreage allotment, even though the acreage of oats grown on rented land was greater than that of corn. The analysis indicated that in each case where oats were grown on rented land there was a net loss in returns. This seems to indicate that perhaps some of the farmers renting land had to rent entire farms to get the corn land they wanted, and planted other crops to get maximum use from the rented area. The results of the 1960 survey tend to support this view. Without the controls on corn, the acreage of corn increased nearly 37 percent, yet it was all grown on land owned by the operators, as were all of the other crops. Therefore, as a result of the controls, the net returns in 1955 were reduced in the aggregate by $5,800 for rent; while in 1960 no rent was chargeable.

In addition to the production costs and the cash rent, the actual cost of fertilizer applied in 1955 and in 1960 was deducted from the gross returns in the respective periods to arrive at net returns. No other adjustments were made in the data for the changed costs involved in increasing the yields per acre during the evaluation period. Other changes in production practices having an effect of efficiency were not determined. In 1955, $1,801 worth of fertilizer was applied on the sample farms, and in 1960, the cost of this input totaled $5,139. Of these amounts, $1,286 and $5,030 worth were applied to corn in 1955 and 1960, respectively.

In 1955, corn was grown for silage on 9 of the 21 sample farms. By 1960 only one of these farms was growing silage. However, all but 5 of the sample farms increased their acreage of corn grown for all purposes by 25 percent during the evaluation period; soybeans increased 80 percent; and alfalfa, 19 percent. The acreage of oats decreased about 35 percent from 1955 to 1960. Total net crop income from the sample farms, computed as explained above with the cost of fertilizer deducted, increased nearly 66 percent during the period of evaluation, from $67,847 in 1955 to $112,536 in 1960.

A market value was applied to all crops harvested, whether they were sold as cash crops or fed to livestock on the farm, so that the crop and livestock enterprises could be analyzed separately. Those homegrown feeds fed to animals on the farm were charged to the appropriate livestock enterprise at the market price. Livestock numbers and net returns are shown in appendix tables 14 and 15.

Changes in livestock numbers resulted in a 28-percent increase in livestock income during the evaluation period. A fixed input-output coefficient was assumed for each class of livestock, so differences in net income shown are due entirely to changes in livestock numbers. The number of beef animals raised increased 107 percent; dairy cows, 31 percent; and beef feeders, 15 percent. The number of hogs raised increased 25 percent; feeder pigs, 29 percent; and sheep, 46 percent. The number of hens decreased 66 percent. There were 2.45 tons of hay grown per animal unit of livestock in 1955 and 2.14 tons in 1960. Of these amounts, 1.92 tons in 1955 and 2.03 tons in 1960 were alfalfa. There was only a small increase in the pasture acreage, but the improved yield, from about 80 animal-unit-days of grazing per acre grazed in 1955 to 90 in 1960, provided adequate forage for the greater livestock numbers. There were about 232 animal-unit-days of grazing available per animal unit for dairy animals, sheep, and beef animals in 1955, and 216 per animal unit of these groups of livestock in 1960. The expanded corn acreage was more than ample to support the approximately 17 percent increase in hog numbers.

The increase in acreage of the higher valued crops, and improved crop yields, coupled with an increase in the number of livestock (poultry excepted), raised the net return to labor, capital, and management by $3,184 per farm. Of this amount, $2,128 resulted from increased crop income and $1,056 from increases in livestock numbers. This is nearly a 46-percent increase in annual farm income. There were more land-treatment measures on the sample farms in 1960 than in 1955, but the data available from the sample farms were not sufficient to allow a determination of the separate effect of these measures on net returns.

The amount and distribution of precipitation, especially during the growing season, greatly influence crop yields. Analysis of the precipitation records indicates the rainfall distribution in 1960 to have been highly favorable in this respect. Data in support of this finding are shown in the appendix.

If the 21-farm sample is representative of the East Willow Creek Watershed, annual farm income between 1955 and 1960 increased by approximately $494,000, of which crop production accounted for $330,000. In contrast, increased crop income computed from studies of land use in the drainage area above structure FD-2 represented $126,000 for the watershed as a whole. Several factors are responsible for the difference in crop income computed by the two methods. On the sample farms, crop yields in 1960 were generally higher than those indicated in area FD-2 for the post project period 1958-60. Also, on the sample farms, yields for the base year 1955 were lower than those for the base period 1954-57 in the drainage area of structure FD-2.

APPENDIX

Gully Erosion

The stabilization and sediment-control structures in the active gullies and land-treatment measures adjacent to them were designed to complement each other in preventing land voiding and depreciation. On the basis of geologic appraisals of sample structures, the gully-control structures installed in the watershed are believed to prevent an average annual loss of 0.12 acre of land from voiding and 0.16 acre of land from depreciating. Monetary benefits of these savings were computed by a method similar to that currently used in planning Public Law 566 projects.8/ Table 10 presents the computations made for determining the benefits per acre of land prevented from voiding or depreciating. For the watershed as a whole, the annual benefit totals only $157.

Precipitation Records, 1956-60

A record of precipitation in the East Willow Creek Watershed from 1956 through 1960 was provided by four gages installed and operated by the U. S. Weather Bureau. Three were in the watershed, and the fourth adjacent to it. The records from the four gages were averaged and are presented in table 11. The average for the 5-year period is included for comparison. It can be seen that 1958 was a dry year, and 1959 was wet. Total rainfall in 1956, 1957, and 1960 was near the 5-year average. The rainfall during the 5 years averaged approximately 28 inches. Records from U. S. Weather Bureau stations in the vicinity of the watershed indicate that the rainfall from 1909 to 1950 averaged 30.24 inches, ranging from 15.38 inches to 43.18 inches. This long-term average is only slightly higher than was observed during the period of evaluation.

During the evaluation period, 70 percent of the precipitation fell in May, June, July, August, and September. In 1958 the total rainfall during May was 0.54 inch, and in May 1959 it was 5.24 inches. Since the three gages within the watershed were installed in January 1956, only the gage adjacent to the watershed was operating during 1955. A comparison of the 1955 record from this gage with the 1960 record from all the gages was made to help isolate one more factor, rainfall, which could have caused the differences observed in yields shown in the prior yield analysis. The 1955 rainfall recorded at Preston, Minn., was as follows:

	Inches		Inches
January	0.16	July	4.07
February	.66	August	.63
March	.78	September	1.80
April	3.13	October	1.23
May	4.02	November	.51
June	2.86	December	1.03
		Total	20.88

8/ U. S. Department of Agriculture. Economics Guide for Watershed Protection, Soil Conserv. Serv., March 1964.

Table 10.--Computation of annual benefits resulting from prevention of land voiding and depreciation, East Willow Creek Watershed, Minn.

	Rotation crops	Pasture	Difference
	Dollars		
(1) Gross income per acre	71.45	16.59	54.86
(2) Cash operating costs per acre	16.00	2.00	14.00
(3) Adjusted gross income	55.45	14.59	40.86
(4) Returns to land less real estate taxes	13.00	3.42	9.58
(5) Real estate taxes	1.33	0.35	0.98
(6) Returns to labor, capital, & management	41.12	10.82	30.30
	Annual loss per acre of land voided		Annual loss per acre of land depreciated
	Dollars		
(7) Loss of income to operator 1/	180.92		133.32
(8) Loss of market value of land resource to owner 2/	216.67		159.67
(9) Loss of real estate tax base to local interests 3/	44.33		32.67
(10) Loss to social interests not reflected in market value of land 4/	216.67		159.67
Total loss per acre	658.59		485.33

1/ Present worth of the annual returns per acre to labor, capital, and management (line 6) decreasing by a constant amount annually over a 10-year adjustment period at 6 percent interest.

2/ Capitalized value of the annual returns to land less real estate taxes (line 4) at 6 percent interest.

3/ Loss or reduction of real estate taxes (line 5) capitalized at 3 percent interest.

4/ Annual returns to land less real estate taxes (line 4) capitalized at 3 percent interest; less loss or reduction in market value of the land resource (line 8).

In 1955, June, August, and September were abnormally dry. May and July rainfall was near the average for those months. In 1960, April, May, August, and september were wetter than average, June rainfall was near the average, and July was a little drier than average.

The distribution of rainfall in 1960 was far more favorable to crop growth than in 1955. Therefore, it is reasonable to attribute part of the yield difference between 1955 and 1960 to a more favorable rainfall pattern in 1960.

Table 11.--Precipitation, monthly and cumulative average, four gages, East Willow Creek Watershed, Minn., 1956-60

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	Inches												
1956	0.50	0.57	2.86	2.88	4.31	3.40	6.28	3.20	1.75	1.47	1.48	0.39	29.09
1957	0.19	0.24	1.04	1.12	3.87	3.84	6.14	5.43	1.56	1.34	3.64	0.66	29.07
1958	0.26	0.10	0.23	1.92	0.54	4.07	2.57	3.15	2.82	0.88	1.60	0.17	18.31
1959	0.53	1.55	2.27	0.87	5.24	7.88	1.43	6.08	4.51	1.44	1.75	1.31	34.86
1960	0.43	0.49	0.70	3.14	5.90	3.41	1.92	6.48	3.40	1.52	0.60	0.53	28.52
Average	0.38	0.59	1.42	1.99	3.97	4.52	3.67	4.87	2.81	1.33	1.81	0.61	27.97
	Cumulative												
1956	0.50	1.07	3.93	6.81	11.12	14.52	20.80	24.00	25.75	27.22	28.70	29.09	
1957	0.19	0.43	1.47	2.59	6.46	10.30	16.44	21.87	23.43	24.77	28.41	29.07	
1958	0.26	0.36	0.59	2.51	3.05	7.12	9.69	12.84	15.66	16.54	18.14	18.31	
1959	0.53	2.08	4.35	5.22	10.46	18.34	19.77	25.85	30.36	31.80	33.55	34.86	
1960	0.43	0.92	1.62	4.76	10.66	14.07	15.99	22.47	25.87	27.39	27.99	28.52	
Average	0.38	0.97	2.39	4.38	8.35	12.87	16.54	21.41	24.22	25.55	27.36	27.97	

Table 12.--Acreage, yield, and net returns, specified crops, 21 sample farms, East Willow Creek Watershed, Minn., 1955

Farm number	Corn for grain			Corn for silage			Oats		
	Acres	Yield	Net return	Acres	Yield	Net return	Acres	Yield	Net return
	No.	Bu.	Dollars	No.	Tons	Dollars	No.	Bu.	Dollars
1 ----	12	60	571	8	14	571	17	30	42
2 ----	50	50	1,030				57	30	-758
3 ----	60	60	2,578				30	40	240
4 ----	90	60	4,009				70	40	560
5 ----	21	40	472	6	6	108	50	35	262
6 ----	61	60	2,805	16	8	502	28	40	224
7 ----	22	65	1,010				25	32	90
8 ----				20	9	703			
11 ----	20	75	1,270	5	11	257	25	50	338
12 ----	37	50	1,369				54	35	284
13 ----	34	78	1,919	9	10	402	30	45	112
14 ----	40	85	2,964				30	35	158
15 ----	34	56	1,052				54	30	-265
16 ----	85	60	3,998	15	6	270	75	50	1,012
17 ----	60	60	2,784	10	8	314	35	50	472
18 ----	20	55	822				35	40	142
20 ----	20	76	1,094				5	35	26
22 ----	35	67	1,806				35	39	-39
23 ----	37	60	1,761				45	33	187
24 ----	13	50	481						
26 ----	46	53	1,261	6	12	348	57	32	-595
Total	797		35,056	95		3,475	757		2,492
Average per farm	38.0		1,669	4.5		165	36.0		119

Farm number	Soybeans			Alfalfa			Other hay			Total of net crop income
	Acres	Yield	Net return	Acres	Yield	Net return	Acres	Yield	Net return	
	No.	Bu.	Dollars	No.	Tons	Dollars	No.	Tons	Dollars	Dollars
1 ----				20	2.0	440				1,624
2 ----				22	1.8	256				528
3 ----				30	3.0	1,260				4,078
4 ----	60	20	1,680	15	3.0	630	18	2.5	531	7,410
5 ----	6	21	180	25	1.5	300				1,322
6 ----				79	3.0	3,318	41	2.0	861	7,710
7 ----				30	3.5	1,560				2,660
8 ----				40	4.0	2,480	15	1.7	130	3,313
11 ----				25	4.0	1,550				3,415
12 ----				13	1.5	156				1,809
13 ----				15	3.0	330	20	4.0	1,100	3,863
14 ----				63	2.0	1,386				4,508
15 ----				20	1.5	240				1,027
16 ----				15	1.5	180	85	1.0	340	5,800
17 ----							29	2.8	1,003	4,573
18 ----				40	2.9	1,600				2,564
20 ----				45	3.0	1,650				2,770
22 ----				64	2.1	1,056				2,823
23 ----				20	4.0	1,240	25	2.0	525	3,713
24 ----				10	2.5	320				801
26 ----				9	3.8	522				1,536
Total	66		1,860	600		20,474	233		4,490	67,847
Average per farm	3.1		89	28.6		975	11.1		214	3,231

Table 13.--Acreage, yield, and net returns, specified crops, 21 sample farms, East Willow Creek Watershed, Minn., 1960

Farm number	Corn for grain			Corn for silage			Oats		
	Acres	Yield	Net return	Acres	Yield	Net return	Acres	Yield	Net return
	No.	Bu.	Dollars	No.	Tons	Dollars	No.	Bu.	Dollars
1 ----	35	85	2,533				17	60	323
2 ----	22	80	814				5	30	12
3 ----	65	95	5,085				26	75	708
4 ----	125	60	5,338				35	60	665
5 ----	40	72	2,413				30	50	405
6 ----	110	80	7,282				40	60	760
7 ----	30	70	1,597				15	40	120
8 ----				30	11	1,432			
11 ----	23	70	1,339				25	60	475
12 ----	58	70	3,303				25	60	475
13 ----	44	85	3,080				10	65	218
14 ----	75	80	5,160				40	45	430
15 ----	15	70	808				15	60	285
16 ----	170	75	8,359				45	40	360
17 ----	60	75	3,695				45	55	731
18 ----	40	80	2,622				20	65	435
20 ----	32	85	2,240				8	60	152
22 ----	38	70	2.175				30	40	240
23 ----	60	65	3,065				40	50	540
24 ----	7	40	185						
26 ----	40	85	2,739				18	80	540
Total	1,089		63,832	30		1,432	489		7,874
Average per farm	51.9		3,040	1.4		68	23.3		375

Farm number	Soybeans			Alfalfa			Other hay			Total of net crop income
	Acres	Yield	Net return	Acres	Yield	Net return	Acres	Yield	Net return	
	No.	Bu.	Dollars	No.	Tons	Dollars	No.	Tons	Dollars	Dollars
1 ----										2,856
2 ----				20	4.5	1,440				2,266
3 ----	20	30	970	25	4.0	1,550				8,313
4 ----	60	20	1,680	35	3.0	1,470				9,153
5 ----				50	3.0	2,100				4,918
6 ----				100	3.0	4,200				12,242
7 ----				25	2.5	800				2,517
8 ----				35	5.0	2,870				4,302
11 ----				40	4.0	2,480				4,294
12 ----				30	4.0	1,860				5,638
13 ----				27	4.5	1,944				5,242
14 ----				60	1.5	720				6,310
15 ----				20	3.5	1,040				2,133
16 ----	35	25	1,339	65	3.0	2,730				12,788
17 ----							40	3.0	1,520	5,946
18 ----	4	25	153	40	3.0	1,680				4,890
20 ----				30	3.0	1,260				3,652
22 ----				50	3.0	2,100				4,515
23 ----				36	5.0	2,952				6,557
24 ----				18	1.7	288				473
26 ----				6	3.0	252				3,531
Total	119		4,142	712		33,736	40		1,520	112,536
Average per farm	5.7		197	33.9		1,607	1.9		72	5,359

Table 14.--Number of livestock and net returns from livestock, 21 sample farms, East Willow Creek Watershed, Minn., 1955

Farm number	Dairy		Beef		Beef feeders		Hogs raised	
	Head	Net return	Head	Net return	Head	Net return	Head	Net return
	No.	Dollars	No.	Dollars	No.	Dollars	No.	Dollars
1 ----	14	2,100					84	840
2 ----	12	1,800					48	480
3 ----	20	3,000			10	360		
4 ----	8	1,200	7	462	7	252	125	1,250
5 ----	15	2,250					48	480
6 ----	27	4,050	40	2,640			140	1,400
7 ----	14	2,100					125	1,250
8 ----	19	2,850						
11 ----	14	2,100					110	1,100
12 ----	12	1,800			12	432	168	1,680
13 ----	17	2,550					200	2,000
14 ----	18	2,700					184	1,840
15 ----	8	1,200			20	720		
16 ----	7	1,050			40	1,440		
17 ----	8	1,200	15	990	20	720		
18 ----	14	2,100					140	1,400
20 ----	14	2,100					60	600
22 ----	22	3,300					104	1,040
23 ----	6	900	6	396			78	780
24 ----	10	1,500						
26 ----	4	600	8	528			115	1,150
Total---	283	42,450	76	5,016	109	3,924	1,729	17,290
Average per farm	13.5	2,021	3.6	239	5.2	187	82.3	823

Farm number	Feeder pigs		Sheep		Hens		Total livestock income
	Head	Net return	Head	Net return	Head	Net return	
	No.	Dollars	No.	Dollars	No.	Dollars	Dollars
1 ----					400	520	3,460
2 ----							2,280
3 ----					300	390	3,750
4 ----					300	390	3,554
5 ----			20	208	50	65	3,003
6 ----			60	624	250	325	9,039
7 ----			20	208	200	260	3,818
8 ----			30	312	50	65	3,227
11 ----					225	292	3,492
12 ----					150	195	4,107
13 ----			30	312	200	260	5,122
14 ----			30	312	200	260	5,112
15 ----	60	525			200	260	2,705
16 ----	100	875			200	260	3,625
17 ----	150	1,312			100	130	4,352
18 ----					50	65	3,565
20 ----					75	98	2,798
22 ----			16	166	150	195	4,701
23 ----			6	62	250	325	2,463
24 ----					50	65	1,565
26 ----					250	325	2,603
Total---	310	2,712	212	2,204	3,650	4,745	78,341
Average per farm	14.8	129	10.1	105	173.8	226	3,731

Table 15.--Number of livestock and net returns from livestock, 21 sample farms, East Willow Creek Watershed, Minn., 1960

Farm number	Dairy		Beef		Beef feeders		Hogs raised	
	Head	Net return	Head	Net return	Head	Net return	Head	Net return
	No.	Dollars	No.	Dollars	No.	Dollars	No.	Dollars
1 ----	14	2,100	14	924			180	1,800
2 ----	16	2,400	7	462			90	900
3 ----	17	2,550			8	288		
4 ----	9	1,350	9	594	9	324	75	750
5 ----	30	4,500					36	360
6 ----	36	5,400	37	2,442			300	3,000
7 ----			24	1,584			175	1,750
8 ----	20	3,000						
11 ----	20	3,000						
12 ----	18	2,700					120	1,200
13 ----	26	3,900					300	3,000
14 ----	25	3,750					170	1,700
15 ----	23	3,450	18	1,188			250	2,500
16 ----	15	2,250	5	330			80	800
17 ----	20	3,000			100	3,600		
18 ----	20	3,000					70	700
20 ----			35	2,310				
22 ----	30	4,500					64	640
23 ----	6	900	8	528	8	288	78	780
24 ----	6	900						
26 ----	20	3,000					180	1,800
Total---	371	55,650	157	10,362	125	4,500	2,168	21,680
Average per farm	17.7	2,650	7.5	493	6.0	214	103.2	1,032

Farm number	Feeder pigs		Sheep		Hens		Total livestock income
	Head	Net return	Head	Net return	Head	Net return	
	No.	Dollars	No.	Dollars	No.	Dollars	Dollars
1 ----			17	177			5,001
2 ----							3,762
3 ----					400	520	3,358
4 ----							3,018
5 ----			25	260	15	20	5,140
6 ----			100	1,040			11,882
7 ----			50	520			3,854
8 ----			50	520	25	32	3,552
11 ----			15	156			3,156
12 ----							3,900
13 ----					200	260	7,160
14 ----			30	312	25	32	5,794
15 ----							7,138
16 ----	200	1,750	7	73			5,203
17 ----	200	1,750					8,350
18 ----					150	195	3,895
20 ----							2,310
22 ----			16	166	125	162	5,468
23 ----					300	390	2,886
24 ----							900
26 ----							4,800
Total---	400	3,500	310	3,224	1,240	1,611	100,527
Average per farm	19.0	167	14.8	154	59.0	77	4,787

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